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ABSTRACT

The Mathematical Sciences Education Board (MSEB) is one of the nine major units of the National Research Council (NRC). It was established to provide a continuing national overview and assessment capability for mathematics education. The NRC's special concern with the quality of mathematics education is based on two considerations: mathematics is the foundation discipline for science and engineering, and therefore plays a key role in the health of the U.S. scientific and technical enterprise; and increasingly, mathematics education will be a significant factor in determining the strength of the nation's workforce and the opportunities open to individuals. This report summarizes the activities and accomplishments of the MSEB, and provides a blueprint for current and future MSEB projects. These projects deal with: (1) national needs and potentials; (2) curriculum and instruction; (3) testing and evaluation; (4) the teaching profession; (5) criteria for excellence; (6) collegiate mathematics; and (7) outreach and communication. (TW)

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ED295784

ANNUAL REPORT of the MATHEMATICAL SCIENCES EDUCATION BOARD

JUNE 1987

The primary purpose of the Mathematical Sciences Education Board is to provide a continuing national overview and assessment capability for mathematics education.

NATIONAL ACADEMY OF SCIENCES/NATIONAL ACADEMY OF ENGINEERING
NATIONAL RESEARCH COUNCIL
2101 CONSTITUTION AVENUE NORTHWEST, WASHINGTON, DC 20418

ANNUAL REPORT
of the
MATHEMATICAL SCIENCES EDUCATION BOARD

JUNE 1987

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BACKGROUND

The Mathematical Sciences Education Board (MSEB) is one of the nine major units of the National Research Council (NRC)*. It was established "to provide a continuing national overview and assessment capability for mathematics education." The NRC's special concern with the quality of mathematics education is based on two considerations:

- o Mathematics is the foundation discipline for science and engineering, and therefore plays a key role in the health of the U.S. scientific and technical enterprise;

- o Increasingly, mathematics education will be a significant factor in determining the strength of the nation's workforce and the opportunities open to individuals.

The MSEB's concern is therefore with excellence in education for all students.

The concept of the Mathematical Sciences Education Board (MSEB) was brought to the NRC by the mathematics community in February 1985. It was endorsed by the Governing Board and resources were provided from the NRC Fund to support its initial activities. The Board was formally launched in October 1985, with a charge to provide:

- leadership of continuing efforts to improve mathematical sciences education nationally

- coordination among on-going educational projects

- service to localities and states, through assistance in determining core competencies for all students and higher standards, and enhancing teacher preparedness

- recommendations on how to strengthen weak parts of the infrastructure of mathematics education

- information to enhance public understanding of the rapidly changing character of the mathematical sciences

- advice to federal, state, and local agencies on long-range goals and needs in mathematical sciences education.

*The National Research Council is the principal operating agency of the National Academy of Sciences and the National Academy of Engineering to serve government and other organizations.

The Board has 34 members and constitutes a unique coalition of mathematics teachers and supervisors, college and university mathematicians, educational administrators, and representatives of government, business, and industry. In the Board membership are the presidents (past, current, and elect) of many of the major organizations concerned with mathematics education and others in national leadership positions in the educational community. Much of the work of the Board is carried out through five committees, each responsible for a permanent area of MSEB concern -- Curriculum, Testing, Teacher Education, Standards, Outreach. The MSEB Executive Committee bears responsibility for basic planning and coordination.

SUMMARY OF ACTIVITIES AND ACCOMPLISHMENTS

In the 20 months since MSEB's inaugural meeting, the Board and its staff have undertaken a broad range of activities, including:

- Development of a Master Plan, containing (i) a careful formulation of MSEB's national leadership role in mathematics education; (ii) an organization scheme for coordinating major programs of activities in six fundamental areas; (iii) specific planning through 1992 in each of these areas; and (iv) a funding plan for support of the activities.

- Development of a draft philosophical framework to guide the reform and revitalization of school mathematics, taking account of national needs, the changing nature of mathematics, and the possibilities for new approaches to the teaching and learning of mathematics presented by computer technology.

- Design of a major study, The Impact of Testing on Mathematics Education, to answer the questions: Do current tests drive the curriculum? Do they tend to reduce learning to a "least common denominator"? Could improved tests be a significant force in improving the curriculum?

- Negotiation of a unique arrangement with the National Council of Teachers of Mathematics for cooperation on the development, review, and dissemination of recommended standards for school mathematics in the 1990s.

- Negotiation of another unique arrangement with the AAAS for cooperation on the mathematics portion of Project 2061.

- Planning and conduct of a national symposium in January 1987, International Comparisons of Mathematics Education: Policy Implications for the United States; arranging for widespread media coverage, preparing slide presentation materials for national dissemination; and cooperating with the National PTA on the distribution of summary information and recommendations to the 25,000 PTA's in the country.

- Organization and conduct of two national conferences at UCLA, The Influence of Testing on Mathematics Education, June 27-28, 1986; The School Mathematics Curriculum: Raising National Expectations, November 7-8, 1986.

- Organization of forums on issues in school mathematics at meetings of the American Mathematical Society and the Mathematical Association of America, the National Council of Teachers of Mathematics, and the American Association for the Advancement of Science.

- Conduct of two joint state conferences on issues in mathematics education: Looking Ahead at the Issues and Focuses of Mathematics Education, Pennsylvania, May 21-22, 1986; Forum on School Mathematics, Minnesota, May 2-3, 1987.

- Laying plans for contacts with governors and state education agencies plus a network of state "mini" versions of the MSEB.

- Development (in cooperation with NRC's Board on Mathematical Sciences) of a proposal for a three-year joint project The Mathematical Sciences in the Year 2000: Assessment for Renewal in U.S. Colleges and Universities to address in the collegiate context the fundamental issues MSEB is attacking at the K-12 level.

- Development (also in cooperation with the Board on Mathematical Sciences) of a proposal for a joint project with the Mathematical Association of America to conduct a mini-study and Fall 1987 symposium Reformation of the Teaching of Calculus, planned to involve members of the science and engineering communities as well as mathematicians, and intended to provide background and advice to the mathematical community and the National Science Foundation with regard to specific calculus curriculum projects.

- Development of plans for a study and symposium Mathematics Education: Wellspring of U.S. Industrial Strength, focusing on the critical need to significantly modify and strengthen mathematics education in the nation's schools in light of concerns about long-term U.S. economic competitiveness.

These activities have not been "free-standing" projects, but carefully selected elements in an overall plan for MSEB's leadership. This Master Plan is described in the next few sections of this report. MSEB is utilizing a "systems" approach to address simultaneously the basic issues in curriculum, instruction, testing, and teacher education and to stimulate change in the infrastructure of education nationally.

PLANS AND PROJECTS

Over the next two decades, the nation's schools must make a dramatic transition in their mathematics programs. Emphasis must shift from drill in paper-and-pencil computations to experience in the use of the conceptual, analytical, and problem-solving techniques of mathematics. This will require a fundamental restructuring of the educational environment from the current "transmission of knowledge" model into one based on "stimulation of learning."

The transition will involve fundamental changes in content, modes of instruction, teacher education, and methods of assessing student progress. Computers will not only displace some of the computational drill that currently dominates the curriculum, but will also open the door to the use of far more sophisticated problem-solving techniques than ever before dreamed of. The dramatic advances that have been made in the mathematical sciences over the past forty years will start to be felt in the schools in the form of new and exciting ways to help young minds order the universe around them.

Although our educational system is grounded in state and local autonomy, textbooks, teacher education, and much of testing in the schools are based on national models. Strong national leadership is required if these are to be significantly modified, leadership which will enable the primary actors in the educational arena -- state and local agencies; teachers and administrators; school boards; professional societies; colleges and universities; publishers, software developers, testmakers; industry; parents; and the general public -- to coordinate a succession of major changes reaching well into the next century.

THE MSEB PLAN

MSEB has organized multi-year studies and projects in these five areas:

National Needs and Potential
Curriculum and Instruction
Testing and Evaluation
The Teaching Profession
Collegiate Mathematics

These studies and projects will develop many of the data, understandings, and recommendations which MSEB will present. Part of the work on these studies and projects will be done by MSEB committees and task forces, and part will be done by other organizations working in cooperation with MSEB. Research, overview, analysis, and experimentation in the five areas will run as strands through the long-term activities of MSEB, and will be carefully planned and phased to feed into a 1988 Report to the Nation, a 1989 Criteria for Excellence Report, and 1992's Second Report to the Nation at appropriate times. The work will then continue -- pointed toward the third major assessment, and beyond.

Parallel to the five strands which determine the basic content of the assessments is an equally important sixth strand which MSEB calls "Outreach and Communication." It is the strand under which are organized mechanisms and activities for communicating with the primary actors in education. At present, these activities fall into four categories:

State and Regional Conferences
Public Information
External Relations
Information Collection and Dissemination

The quality and extent of activities in these categories will play a major role in determining the acceptance of MSEB recommendations.

Organizing the Work

MSEB projects vary significantly in duration and in type, from three-year comprehensive studies to one-year research projects, series of topical conferences, and even one-shot consciousness-raising symposia. Some are joint with other organizations. When possible, large projects simply incorporate directly parts of the work done elsewhere.

The complexity of the overall effort poses a potential puzzle for anyone on the 'outside' trying to understand how the pieces fit together to form a coherent program. Fortunately, the narrative description presented in the previous section has a simple graphic representation which explains what MSEB is doing and shows where the pieces fit.

The chart, which appears on the next page, is a matrix in which rows represent years and columns represent project strands. Projects and studies are staged so that:

- At the time of a major assessment the recommendations form a coherent package -- an across-the-board, in-depth look at mathematics education, together with a road map which can be used by states, localities, schools, teachers, colleges, publishers, testmakers, etc. in future development and planning;

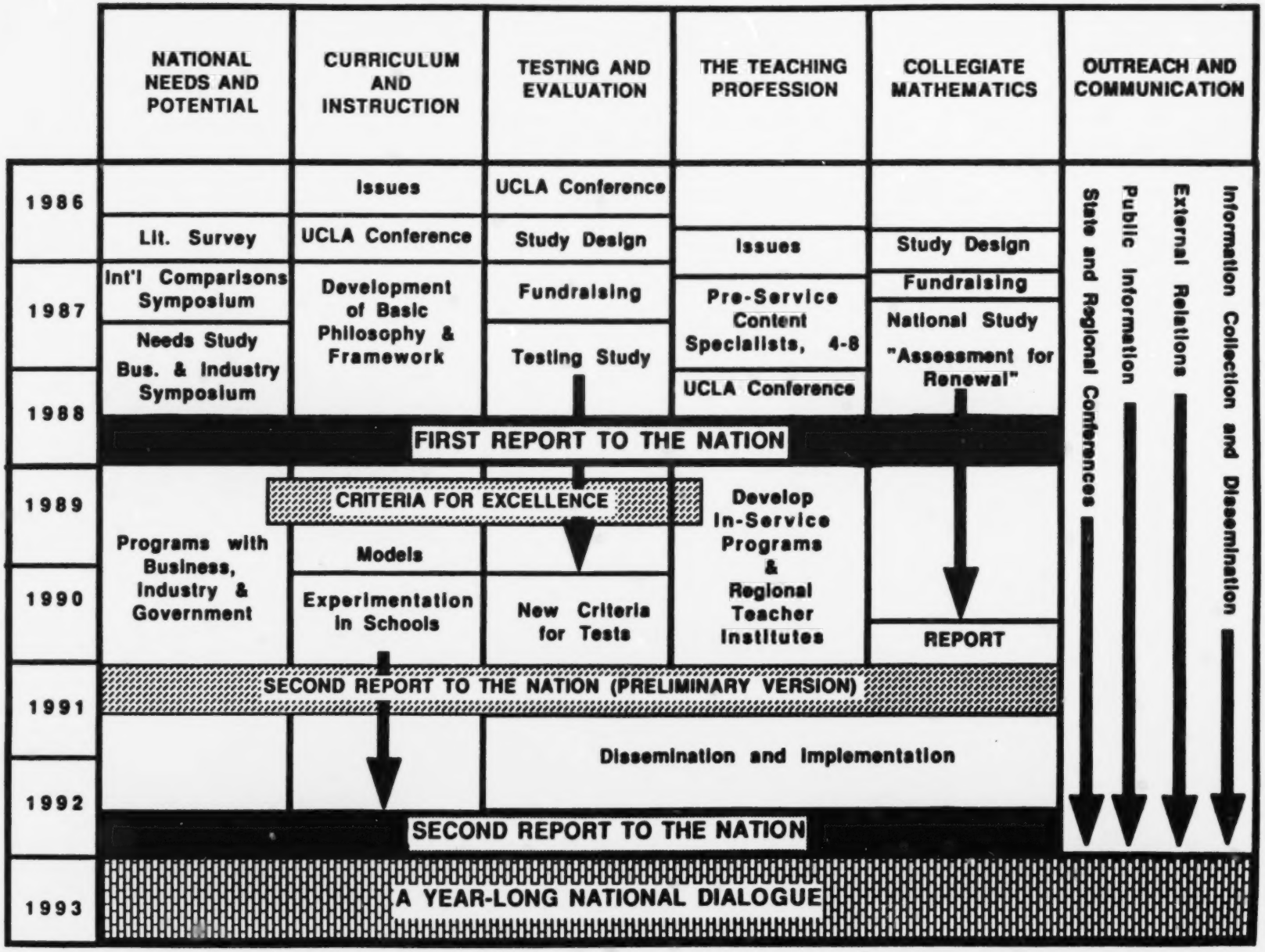
- Widespread discussion of issues and recommendations will take place throughout the country before and after each assessment, to help insure that these are understood and well-received.

Schematically, each overview and analysis report is shown as a horizontal band cutting across the columns, to indicate that it relies on the state of knowledge within the strands at the time of the report.

The primary message of the chart is that MSEB is engaged in a continuing effort to help states and localities to answer five basic questions which are always with them: What needs are we trying to meet?; What should the curriculum look like and how should it be presented?; Who will present it and what help will they need?; How will we know if the process works?; and, Meanwhile, what will or should the colleges be doing?

MSEB's main interest is in helping the whole system move forward -- by identifying the most fundamental questions, by synthesizing the best thinking in the country, and communicating regularly with all the principal actors.

A brief description of the projects in and across each of the strands follows the chart.


NATIONAL NEEDS AND POTENTIAL
CURRICULUM AND INSTRUCTION
TESTING AND EVALUATION
THE TEACHING PROFESSION
COLLEGIATE MATHEMATICS
OUTREACH AND COMMUNICATION
1986
1987
1988
1989
1990
1991
1992
1993
Issues
UCLA Conference
Lit. Survey
UCLA Conference
Study Design
Issues
Study Design
Int'l Comparisons Symposium
Development of Basic Philosophy & Framework
Fundraising
Pre-Service Content Specialists, 4-8
Fundraising
Needs Study
Bus. & Industry Symposium
Testing Study
National Study "Assessment for Renewal"
UCLA Conference
FIRST REPORT TO THE NATION
CRITERIA FOR EXCELLENCE
Develop In-Service Programs & Regional Teacher Institutes
Programs with Business, Industry & Government
Models
Experimentation in Schools
New Criteria for Tests
REPORT
SECOND REPORT TO THE NATION (PRELIMINARY VERSION)
Dissemination and Implementation
SECOND REPORT TO THE NATION
A YEAR-LONG NATIONAL DIALOGUE
State and Regional Conferences
Public Information
External Relations
Information Collection and Dissemination

THE MSEB PROJECTS

1. National Needs and Potential

International Comparisons

It was not by accident that the publicly visible work of the MSEB began with a national symposium, International Comparisons of Mathematics Education: Policy Implications for the United States, funded by the National Science Foundation and held at the National Academy of Sciences in Washington, January 15-16, 1987. Its purpose was to begin the broader public education task necessary for meaningful change to occur, by communicating a three-tiered message based on the research in recent international studies: (i) the problems are serious -- mathematics achievement of U.S. students is low relative to that of their counterparts in other industrialized countries; (ii) most of the quick-response explanations one hears put forth for the weak performance of our students are demonstrably incorrect; (iii) in thinking about problems and solutions, our minds need to be on such important findings as these:

- U.S. students are somewhat weak in computational skills, but very weak on problem-solving and higher order thinking skills, the very things we as a nation most need to strengthen if we are to compete effectively in the international marketplace.

- Our mathematics curriculum lies at the heart of our difficulties, its most glaring deficiencies being that it continually cycles backward over topics not mastered in the last go around and that it deals inadequately with understanding and mastery of the uses of mathematics to solve real problems in the real world.

- Another basic difficulty appears to lie in the marked differences which exist between the U.S. and key industrial countries concerning parental and school expectations regarding the learning of mathematics.

MSEB efforts to continue conveying these and other basic messages to the public have included widespread newspaper coverage, a speaker's guide to be used by several hundred individuals in making presentations around the country, and a short "alert" sent to 25,000 PTA's around the country by the National PTA President (who serves on the MSEB Executive Committee).

Economic Competitiveness

During the coming year MSEB hopes to continue such "awareness" efforts and create a second level of understanding of national needs by conducting a national symposium called, Mathematics Education: Wellspring of U.S. Industrial Strength, with the following central themes:

> Our future economic well-being, especially our ability to compete successfully in the international marketplace, is critically dependent on the mathematics programs in our nation's schools. We must provide a different and higher quality mathematics education for all students. The mathematics curriculum will continue to be the gateway to science and engineering. More importantly, as the only organized technical curriculum grades K-12, it must

also serve as the locus for developing the nation of "problem-solvers" now recognized as essential for the country's future workforce.

The symposium would draw together leaders from business and industry; members of the Academies; other mathematicians, scientists, and engineers; educators and education policy-makers; plus highly-visible representatives of the public sector, for a day-and-a-half of intensive discussion and planning. The focus would not be on how mathematics skills as we learned them relate to current needs in different employment categories, but on the potential of a modified mathematics program for providing the problem-solving skills for a stronger workforce. Discussion would be based on a set of issue papers, specifically linking the long-term health of business and industry to impending changes in school mathematics. The work of the study and symposium would be done during a one-year period under the guidance of a Steering Committee chaired by a leading industrial figure.

Human Resources

One of the fundamental realizations of the 1980's is that concern with the quality of technical education for all citizens is a national imperative. We must be intensely concerned both with equality of opportunity and with getting the most out of the talent inherent in our dwindling supply of young people, especially with utilizing the brainpower of women and minorities.

In the case of mathematics education, the argument is even more forceful. Mathematics is both the enabling discipline and the critical filter for the technical preparation of our young people, not only for careers in science and engineering per se, but also for entry into all sectors of the workforce. The quality and extent of the general student's mathematics education, at a given level of school or early college, largely determines the pool of individuals available for entry into technical careers or into the next level of education. Lose them at any one level, and they almost never reappear in the pool.

Thus concern with human resources and talent pervades MSEB's work. One targeted project for which planning has begun is Making Mathematics Work for Minorities, to include (i) a long-range information campaign aimed principally at minority students from pre-school through high school, and (ii) special efforts for shorter-term results at the collegiate level.

2. Curriculum and Instruction

Talk about "a nation of problem-solvers" seems a far cry from where we are today in the United States. Yet, that is the challenge. Just as present curricula are part of our problem, the mathematics curricula of the future must be designed to meet the challenge. Shortly after its inception, the MSEB launched a multi-year curriculum project to do just that.

It should be stressed that the goal of MSEB is not to write or create a national curriculum. It is to develop a framework, a skeleton if you will, which points the way for those charged with the responsibility of writing actual curricula and which helps ensure some consistency among state and local curricula. Issues of instruction are inextricably linked to content and will be dealt with at the same time and at the same general level.

The first phase of the work was assigned to a Curriculum Task Force, led by Professor Anthony Ralston of the State University of New York at Buffalo. Using the experience and knowledge of its members, each expert in some aspect of school mathematics, plus a review of existing programs and studies and feedback from the UCLA and Minnesota conferences mentioned earlier, the group has spent a year developing a draft report containing:

- o A philosophical framework to inform development of a new K-12 mathematics curriculum;
- o Identification of specific issues which need to be addressed in subsequent development of a new mathematics curriculum;
- o Identification of areas of research to be pursued to inform decisions about curriculum development.

Earlier forms of the draft were used as background for the conferences mentioned. The summer of 1987 begins a new phase, which will encompass: review of the draft document, especially its philosophy statement, by the best brainpower in the country; planning and organization for the work of several panels, to produce models for the scope and sequence of alternative curricula which fit the general framework.

The final report of the Task Force will be submitted by January 1988, and published as an interim report of MSEB so that it can be used as the basis for widespread dialogue. Its discussion will involve concentrated effort to clarify the most difficult issues pinpointed by the Task Force Report, such as:

> How should the organizing principles of the elementary school mathematics curriculum of the future be articulated?
>
> What will or should be the extent of integration of mathematics and science curricula?
>
> Can engineering principles and methods be made part of the teaching of mathematics?

It is expected that these issues will be sufficiently resolved by the summer of 1988 that a description of the MSEB philosophy and framework will appear in the fall Report to the Nation.

Later phases of the Curriculum Project will encompass: (i) development of alternative models for future-oriented frameworks; (ii) experimentation in the schools, possibly in cooperation with AAAS' Project 2061; (iii) assistance to states and school districts in adaptation of the MSEB models to local needs.

3. Testing and Evaluation

Concern about the impact of testing on curricula, instruction, and student attitudes is growing, at the same time that use of tests to assess student progress is expanding. Consolidation is a current issue, as is the efficacy of multiple-choice tests. More pressing for mathematics, perhaps, is the fact that calculators are not widely used in the classroom because tests have not been

adapted to their use. There is also the fundamental long-term issue: tests need to be modified and up-dated regularly if they are not to act as obstacles to curricular reform and other improvements.

MSEB's work on testing has proceeded as follows. Two forums on testing were held at professional meetings, one at the Joint Mathematics Meetings in New Orleans in January 1986 and another at the annual meeting of the National Council of Teachers of Mathematics in April 1986. A national conference on The Influence of Testing on Mathematics Education was held at UCLA in June 1986. These forums and the UCLA conference identified issues in testing, both for the benefit of professionals who establish policy concerning the design and use of tests and for the benefit of MSEB in planning its activities in this sphere.

Current Tests

In August 1986, MSEB brought together a three-person Design Task Force to review the issues and design a study to address them. This group selected as most pressing those concerning the validity of the standardized achievement tests for adequately measuring achievement in mathematics, for testing higher order thinking skills, etc. Top priority was accorded the issue of alignment between important new objectives (e.g., problem-solving) and the test items.

The Task Force developed a design for a three-part study of the impact of testing, as seen from the student perspective, teacher perspective, and the public's perspective. It involves surveys, classroom observations, interviews, analysis of test construction, and various follow-up activities. The National Science Foundation will support the initial phases of this study. MSEB is seeking to have the later phases undertaken by a university-based research team in cooperative arrangement with MSEB.

Alternative Tests

The MSEB Testing Committee will hold a hearing in the fall of 1987 on Assessing Achievement in the Mathematics Curriculum of the Future. This hearing will inform the Board about existing and hypothesized alternative modes of testing that are consistent with the mathematics curriculum framework planned for the future. Based on this information, guidelines for new assessment instruments and techniques will be developed.

4. The Teaching Profession

Over time, the NRC must be informed about and concerned with a wide variety of aspects of the teaching profession: teacher certification, teacher supply and retention, teacher preparation and education, both initial and continuing. MSEB's highest priority in this complex area must be assigned to projects which can have a direct impact on the ability of the nation's teaching force to deal with curricular and instructional changes recommended in MSEB assessments.

The philosophy developed to guide the evolution of curriculum and instruction may represent a dramatic change in the dominant philosophy of school mathematics. Now that its outlines are coming into focus, the MSEB Teacher Education Committee is organizing a Fall 1987 national conference (probably at

UCLA) to help formulate MSEB's action plan in teacher education. Some of the key issues are:

Pre-service Education: The question of who is going to prepare future teachers and how is very complex. The present structure of teacher education does not seem well-suited to deal with the shifts MSEB foresees in curricular and instructional philosophy, nor do the mathematics departments in the universities. Several groups have recommended abolition of the undergraduate education major. National certification boards are being actively discussed. (Several MSEB members, including the MSEB Chairman Dr. Shirley Hill, are directly involved in the general reform effort.) MSEB's role will be to bring a strong disciplinary understanding to the continuing debate and help define what makes sense for the preparation of future teachers in the current climate for reform, given the context of the new curricula.

Specialists Teachers, Grades 4-8: Mathematics education becomes a more formidable task after about grade 3. MSEB will oversee a series of activities concerned with the necessity/advisability of using specialist teachers to handle mathematics in grades 4-8 and will make recommendations on the preparation and use of such specialists.

Structured In-Service Programs: Even if the expected large turnover in the teaching force occurs, a large percentage of in-service teachers will be in need of additional mathematical, statistical, and computer science knowledge and experience for many years to come. High priority must be given to the continuing education of mathematics teachers through programs designed to have a cumulative effect over an extended period of time. Recommendations on the quantity and quality of such programs will be formulated by MSEB and communicated in the Report to the Nation and/or other publications.

Regional Teacher Institutes: MSEB may propose that a network of large teacher institutes be established, and work to that end with state and regional groups, colleges and universities, the Department of Education, the National Science Foundation, and other sponsoring or funding agencies. Such institutes may be necessary to enable the professionals to develop curricula from new frameworks and become familiar with new methods of instruction.

5. Criteria for Excellence

For mathematics curricula to change, a wide variety of standards must change concurrently, or implementation and improvement will be impossible. We need standards in our schools which are criteria for excellence, and we need some consistency from one school or district to another.

MSEB will work jointly with NCTM to develop and disseminate recommended standards for mathematics curriculum, instruction, and evaluation, K-12. This project will relate to MSEB's work on curricular frameworks and testing already under way. Development work will be done by NCTM, while MSEB provides: (i) input as the development goes along, especially input on initial curricular frameworks; (ii) review and oversight at each stage; (iii) organization of hearings or conferences to discuss the standards and make them available to states.

Draft standards will be available in the fall of 1987. MSEB is planning for intensive reviews by 30 ten-member groups, four each of parents, school board members, curriculum supervisors, school administrators, business and industry members, mathematicians, scientists and engineers, plus two of chief state school officers. Careful attention will be paid to geographical distribution of the groups. A written feedback report will be provided for the NCTM Commission prior to redrafting the standards in the summer of 1988.

The NCTM standards in final draft form will be reviewed by the MSEB during the fall of 1988, with the intent that NCTM will publish its professional standards in February 1989, hopefully with MSEB endorsement, and that MSEB will use the standards as bases for discussions with the National Governors Association, the Council of Chief State School Officers, etc., and for an extensive set of state and regional hearings.

Planning for the MSEB role is currently being completed and funding sought for carrying on the review process in 1987-88 and the nationwide dialogue about standards in 1989-90.

The relationship of the Criteria for Excellence project to the major MSEB projects on curriculum and instruction, testing, and teacher education might be described in this manner:

> If there is widespread adoption of the NCTM's professional standards, then by the mid 1990s the nation's schools will be positioned to deal with the more 'revolutionary' curricula, modes of instruction, and methods of evaluation suggested by MSEB's fundamental work, and a new era in mathematics education will dawn at just about the turn of the century.

6. Collegiate Mathematics

A 1986 National Science Board committee report says that the nation's undergraduate programs in science, mathematics, and engineering "have declined in quality and scope to such an extent that they are no longer meeting national needs." This poses a "grave, long-term threat to the nation's scientific and technical capacity, its industrial and economic competitiveness, and the strength of its national defense." [Report of the NSB Task Committee on Undergraduate Science and Engineering Education to the National Science Board, March 20, 1986.]

Work over several years by committees of the American Mathematical Society, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics has painted an equally worrisome picture of the general scene in college and university mathematics departments across the nation. For the MSEB, these issues are of concern in their own right, but are vitally important for another reason: no large-scale change in school mathematics is possible unless it is consistent with the general philosophy and approach to mathematics taken in the nation's colleges.

The Collegiate Project

A multi-faceted, multi-year study, The Mathematical Sciences in the Year 2000: Assessment for Renewal in U.S. Colleges and Universities, will be undertaken jointly by MSEB and NRC's Board on Mathematical Sciences (BMS). Joint sponsorship will ensure continuing broad perspective and support for this project within the mathematical sciences community. (The basic outlines of such a proposed study were brought to the NRC by that community as an outgrowth of the committee work mentioned.)

The study will include:

- Analysis of data to provide a national assessment of needs, resources, and opportunities in collegiate mathematics;
- Consideration of standards for curricula, faculty, resources quality, and productivity of college mathematics departments;
- Recommendations for action by various organizations responsible for higher education: colleges and universities, federal agencies, state governments, foundations, professional societies, and college faculty.

The importance of this effort derives not only from the fundamental role of mathematics in educating scientists, engineers, computer scientists, managers, etc., but also from some critical problems which need attention:

- The failure of many mathematics departments to present mathematics in the context of its greatly-expanded applications to science and engineering, and to adapt to the ubiquity of modern computers;
- The unusually large teaching loads in mathematics departments (except at prestige universities) -- loads deriving from a decade in which enrollments doubled with no increase in faculty size;
- A range of manpower problems, including aging faculties, decreased Ph.D. production, high percentages of Ph.D. candidates who are foreign nationals, low numbers of undergraduate mathematics majors, and the virtual exclusion of many minority groups.

Of course, serious problems in these three areas -- curriculum, resources and talent -- exist in most fields of science and engineering, but are particularly acute in mathematics. Moreover, mathematics can be viewed as the gateway to success in other sciences and engineering, thus addressing these issues in mathematics has special urgency.

Professor Bernard Madison of the University of Arkansas spent the fall of 1986 at the NRC, heading up a proposal development and study design group. Interim funding has been obtained to continue Dr. Madison for the next six months. Funding is being sought so that the full study can begin early in 1988.

Calculus Reform

As a part of the overall collegiate effort, MSEB and the Board on

Mathematical Sciences, together with the Mathematical Association of America, have formulated a special project to provide leadership on the reform of the teaching of calculus. The state of the teaching of calculus and the need for reform have been widely discussed within the mathematical sciences community for the past eighteen months. Out of these discussions has come general agreement that reform is needed. A number of experimental projects are already underway on campuses across the country. In addition, the National Science Foundation has requested funds in the 1988 Fiscal Year allocation to support a large number of additional pilot projects in new ways to teach calculus.

To help create a national environment favorable to the reform and improvement of calculus teaching and ensure that pilot teaching projects are based on a common high-level information base, MSEB and BMS are seeking funding for a major national conference on calculus reform, Reformation of the Teaching of Calculus: Development of a Common Information Base for Innovations & Pilot Projects, to be held at the Academy in October 1987. The conference will involve, both as speakers and participants, leaders from the mathematical sciences community and from science, engineering, social science, business, industry, and educational administration. In conjunction with conference, a comprehensive report will be prepared addressing the fundamental issues of content, teaching methods, uses of technology, the needs of client disciplines, impact on mathematics departments and on client departments, and other pertinent issues. Professor Lynn A. Steen of St. Olaf College will direct the project. Funding is being provided by the Sloan Foundation.

7. Outreach and Communication

It is anticipated that virtually every group and organization in the United States which concerns itself in some way with mathematics education will benefit from the work of MSEB, just as MSEB will benefit from the work and inputs of such groups. The involvement of many professional organizations long before conclusions are reached and recommendations are finalized is seen to be quite important. The widespread involvement of those legally responsible -- state and local education agencies -- is of paramount importance.

MSEB intends not just to communicate its conclusions to education agencies and other groups, but to engage them in the process of formulating the conclusions. This will insure that MSEB recommendations do not come as pronouncements from "on high," but as statements of common understandings. In many cases, it is hoped that implementation will already be well underway before public release of MSEB recommendations.

The quality of the channels of communication and working relationships developed by MSEB will be a major factor in determining the effectiveness of its program. Planning for this communication effort is presently done in four areas.

Activities initiated in the last year include:

- o A series of state conferences on issues in mathematics education, the first held in Pennsylvania in May 1986 and the second held in Minnesota in May 1987;

- o Negotiations with consultants to plan extensive contacts with state education authorities and a network of state "mini" versions of the MSEB;

- o Use of the professional staff of the mathematics community's Office of Governmental and Public Affairs to augment NRC staff in public information, when appropriate.

These efforts will continue in the coming year, as will what is perhaps the most critical activity of MSEB in this arena: the establishment and maintenance of contact and working relationships with key organizations, groups and individuals concerned with mathematical sciences education.

The means of communicating with these groups and with key individuals will include such things as:

- o Direct communications from individual MSEB members to their professional colleagues, and particularly to their professional associations at their meetings and through their publications;

- o Staff-to-staff contacts with key organizations;

- o Communiques from MSEB as a part of its "external relations" effort:

  - mailings to the MSEB mailing list;

  - presentations at selected professional meetings by the MSEB chairman, executive director, members of the Executive Committee, and others acting officially on behalf of MSEB;

  - and an MSEB newsletter;

- o Wide dissemination of "issue papers" and major reports to officers and key individuals in professional organizations, utilizing existing networks in the professional societies and other means.

An important part of regularizing these contacts will be the establishment of a sophisticated MSEB database. MSEB will be a pilot project in NRC's expanded database effort in the coming year.

FUNDING

MSEB's projects can be regarded as falling into two categories:

I. Education Research and Development

II. Overview, Analysis, and Communication

The R&D projects will require funding of several million dollars per year in the steady-state, and it is hoped that much of the support for these projects will be supplied by the users (state and local school districts). Initially, funding for R&D projects is being obtained from the National Science Foundation and from private foundations, with additional funding still to be sought from a variety of sources, including the Department of Education. Much of this R&D work will be carried out through joint projects with other organizations. The activity level will probably average $1,000,000 - $2,000,000 for the next few years.

Support for Overview, Analysis, and Communication projects was initially obtained from the Teagle Foundation and is being sought from Federal science and education agencies for the next 5 years. Estimated costs of these 'core' projects are $750,000 - $1,000,000 per year during that period.

Specifics for Fiscal Years 1986 - 1988

The original $325,000 in start-up funds contributed by the NRC were augmented by a $328,000 grant from the National Science Foundation to support work on curriculum frameworks and testing over the period March 1986 - February 1987. NSF also provided $85,000 in support for the project on international comparisons in mathematics education, which included the January 1987 symposium plus development and dissemination of the speaker's guide.

In-kind contributions from universities and professional organizations over the first 20 months of MSEB's existence are estimated at $353,000.

Looking to the near future, available and expected resources include: a continuation grant from the National Science Foundation to support parts of MSEB's work on curriculum frameworks, testing, and teacher education over the coming year; a three-year core funding grant from the Teagle Foundation; transition-year funding supplied by the National Science Foundation for the collegiate project "MS2000" (joint with BMS); Sloan Foundation support of the Calculus Project; and anticipated core funding grants totalling $500,000 - $750,000 per year for 5 years, to come from a coalition of federal science agencies, probably including the Air Force Office of Scientific Research, Army Research Office, Defense Advanced Research Projects Agency, Department of Energy, National Aeronautics and Space Administration, National Institutes of Health, National Security Agency, and Office of Naval Research, as well as the Department of Education and several units of the National Science Foundation.

MSEB also plans to seek several additional project grants from the National Science Foundation, the Department of Education, and the Carnegie Corporation of New York, plus other private foundations and corporations.

CONCLUSION

MSEB has started to create interest and excitement in the many constituencies with vital interests in mathematics education. People are beginning to understand its unique role and to see that the kinds of oversight, stimulation, amplification, coordination and widespread consultation it engages in are just what was missing from earlier efforts to improve mathematics education.

From the very beginning, MSEB was envisioned as reaching out far beyond the traditional mathematics and mathematics education communities, actively engaging the broad range of individuals and organizations who have a legitimate stake in the outcomes of mathematics education. This dream has become a daily part of its modus operandi, influencing virtually every decision about membership on the Board and its committees, invitations to conferences and symposia, and dissemination of information.

Confidence and support for MSEB as a vehicle for change have been openly expressed by key officials of the National Science Foundation and the Department of Education, by the Council of Scientific Society Presidents, by the Science Advisor to the President, and by the many individuals and organizations eager to work with MSEB.

The first year-and-a-half's experience has reinforced the sense which the NRC Governing Board had in establishing MSEB, that the time and conditions, if not perfect, are as good as they are ever going to be to bring about the truly revolutionary changes in mathematics education in U.S. schools and colleges which are so badly needed.

Mathematical Sciences Education Board
1986-1987
Membership Roster

Shirley A. Hill, Chairman; 1988
Professor of Mathematics
and Education
University of Missouri-Kansas
City
(mathematics education)

Gordon M. Ambach; 1987
Commissioner of Education
State Education Department
State of New York
(education policy and
administration)

J. Myron Atkin; 1989
Professor, School of Education
Stanford University
(education policy and
administration)

NAS David Blackwell; 1988
Professor of Statistics
Statistics Department
University of
California-Berkeley
(research mathematician)

Gail F. Burrill; 1987
Chair, Department of Mathematics
Whitnall High School
(Wisconsin)
(mathematics classroom teacher)

Iris M. Carl; 1989
President-Elect, National
Council
of Supervisors of Mathematics
Elementary Mathematics
Instructional Supervisor
Houston Independent
School District
(mathematics classroom teacher)

Responsible Staff Officer
Marcia P. Sward, Executive
Director

C. Herbert Clemens; 1987
Professor of Mathematics
University of Utah
(research mathematician)

Hirsh G. Cohen; 1987
Vice President,
Divisional Operations
IBM Research
(Liaison member, CPSMR)
(applied mathematics)

Clyde L. Corcoran; 1987
Mathematics Teacher
California High School
(mathematics classroom teacher)

F. Joe Crosswhite; 1987
Past-President
National Council of
Teachers of Mathematics
Professor, Northern Arizona
University
(mathematics education)

Richard de Aguero; 1988
Director of Student Activities
Miami (Florida) Senior High
School
(mathematics classroom teacher
and secondary school principal)

Morris DeGroot; 1987
Professor of Statistics and
Industrial Administration
Statistics Department
Carnegie-Mellon University
(Liaison member, CBASSE)
(statistician)

William J. Dennis, Jr.; 1988
Senior Research Fellow
Research and Education
Foundation of the National
Federation of Independent
Business, Inc.
(business and industry)

John A. Dossey; 1989
President, National Council of Teachers of Mathematics
Professor of Mathematics
Illinois State University
(mathematics education)

James T. Fey; 1988
Professor of Curriculum and Instruction and Mathematics
University of Maryland
(mathematics education)

Robert Glaser; 1987
Director, Learning Research and Development Center
University of Pittsburgh
(cognitive psychologist)

NAS Andrew Gleason; 1989
Hollis Professor of Mathematics and Natural Philosophy
Harvard University
(research mathematician)

Neal Golden; 1988
Chairman
Computer Science Department
Brother Martin High School (Louisiana)
(classroom teacher)

Gene L. Hoffman; 1987
State Representative, Illinois House of Representatives
(state legislature)

Joseph R. Hoffmann; 1987
Consultant in Mathematics Education
California State Department of Education
(mathematics supervisor)

Kenneth M. Hoffman; 1989
Professor of Mathematics
Massachusetts Institute of Technology
(research mathematician)

David R. Johnson; 1989
President, National Council of Supervisors of Mathematics
Chairman, Mathematics Departme
Nicolet High School (Wisconsin)
(mathematics supervisor)

Ann P. Kahn; 1988
President, The National PTA
(education policy and administration)

Jeremy Kilpatrick; 1987
Professor of Mathematics Education
University of Georgia
(mathematics education)

Joan R. Leitzel; 1987
Professor of Mathematics and Associate Provost
The Ohio State University
(collegiate mathematics faculty)

Peggy C. Neal; 1988
Mathematics Teacher
Burney Harris Lyons Middle School (Georgia)
(mathematics classroom teacher)

Henry O. Pollak, Vice Chairman; 1989
Assistant Vice President (Retired)
Mathematical, Communications and Computer Sciences Research Laboratory
Bell Communications Research
(business and industry)

Jack Price; 1988
Superintendent of Schools
Palos Verdes Peninsula Unified School District
Palos Verdes, California
(education policy and administration)

Anthony Ralston; 1989
Professor of Computer Science and Mathematics
State University of New York at Buffalo
(computer scientist)

Stephen B. Rodi; 1988
President, American Mathematical
Association of Two-Year
Colleges
Division Chairperson
Mathematics and Physical
Sciences
Austin Community College
(two-year college faculty)

Frederick A. Roesch; 1989
Senior Vice President, Global
Electronic Marketing
Citibank, N.A.
(business and industry)

Paul Sally; 1987
Professor of Mathematics
University of Chicago
(research mathematician)

C. Thomas Sciance; 1987
Director, Engineering Research
E.I. du Pont de Nemours and Co.
(business and industry)

Lynn Arthur Steen; 1989
President, Mathematical
Association of America
Professor of Mathematics
St. Olaf College
(collegiate mathematics faculty)

Dorothy S. Strong; 1988
Director of Mathematics
Chicago Public Schools
(mathematics supervisor)

Calvin J. Wolfberg; 1988
Past-President
Pennsylvania School Boards
Association
(education policy and
administration)

* Note all terms end in June.

Mathematical Sciences Education Board
1987-1988
New Member Roster

C. Diane Bishop; 1990
State Superintendent of Public Instruction
Arizona Department of Education
(education policy and administration)

Shirley A. Frye; 1990
Director of Curriculum and Instruction, Scottsdale School District (Arizona)
(mathematics education)

Donald L. Kreider; 1990
Vice Chairman, Mathematics and Computer Science Department,
Dartmouth College
(research mathematician)

NAS Martin D. Kruskal; 1990
Department of Mathematics and Applied Mathematics
Princeton University
(astrophysicist)

Katherine Layton; 1990
Beverly Hills High School
(California)
(classroom teacher)

Steven J. Leinwand; 1990
Mathematics Consultant,
Connecticut State Department of Education
(mathematics supervisor)

Gail Lowe; 1990
Principal, Arcadia Elementary School
(California)
(education policy and administration)

Lauren B. Resnick; 1990
Learning, Research and Development Center
University of Pittsburgh
(cognitive psychologist)

Yolanda Rodriquez; 1990
Agassiz School
(Massachusetts)
(classroom teacher)

Thomas A. Romberg; 1990
Professor, Department of Curriculum & Instruction
University of Wisconsin at Madison
(mathematics education)

Ted Sanders; 1990
Superintendent of Education,
(Illinois)
(education policy and administration)

Nellie C. Weil; 1990
Past President, National School Boards Association
(Alabama)
(education policy and administration)

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